E/CONF.39/C/444
2 Nov.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: C.8.1

Japan

SHALLOW SEA AND INLAND SEA FISH AND SHELLFISH CULTURAL TECHNIQUES, PARTICULARLY ARTIFICIAL SEED CULTURE DEVELOPMENT

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(583, C, 8, 1)

SHALLOW SEA AND INLAND SEA FISH AND SHELLFISH CULTURAL TECHNIQUES, PARTICULARLY ARTIFICIAL SEED CULTURE DEVELOPMENT

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1. Marine aquiculture is one of the most effective methods which utilize the rich productivity of fertile inshore waters. In Japan, commercial culture of various marine species of fish, shellfish, crustaceans, cephalopods and larger algae have been commenced in recent years, in parallel with the general development of conventional types of marine aquiculture. And attempts have still been made to improve the culturing techniques for those species as well as additional species on commercial basis.

2. In this paper, the stage of development of culture technique is indicated for each of the 31 important species of marine animals.

3. The installations that are used for culturing the abovementioned marine animals are classified into 7 types. Each type is described briefly and its advantages and disadvantages are discussed.

4. Some of the practical problems encountered in conducting above conventional types of culture are discussed herein.

I. INTRODUCTION

1. Until recent years, seaweeds such as laver (or Nori), edible oyster and pearl oyster and shellfishes have been the major items, commercially cultured in the shallow inshore seas along the coast of Japan. Commercial culture of marine fishes and crustaceans were also conducted in these waters, but this was done for the purpose of the 'livekeeping' (i.e., keeping the fish alive during the season(s) of low market price) and not for growing the fish, with the exception of a few species.

2. In recent years, there has been quickly growing the commercial culture of those fishes, crustaceans and mollusks which are highly prized by our people, owing to rising prices of these species and to the need on the fishermen's side to compensate for their declining income derivable from

inshore fishing. It should not be overlooked, however, that this rapid growth would not have been possible if the physiology and ecology of these species had not been studied in past years and if such new materials as synthetic fibres, concrete piles, etc. had not been available.

3. In this report the representative methods that are now used in Japan for the commercial culture of marine fishes and shellfishes are described and reference is made to those factors that should be taken into account in constructing marine fish-farms. Methods of seaweed culture are omitted.

II. COMMERCIALLY CULTURED SPECIES

4. Fish, cephalopods, crustaceans and shellfish (both bivalves and gastropods) are the major animal groups that are now commercially cultured in the Japanese inshore waters. The major species are listed in TABLE 1 by these groups.

5. At present, the prawn (Penseus japonica) is the only species that is cultured commercially throughout its life history (i.e. from the artifically fertilized egg through larval stages up to the marketable size) In the other species, commercial culture starts with naturally spawned eggs collected at sea or in the later growth stages.

6. In all the 16 fish species listed in TABLE 1, commercial culture starts with the seedlings which are collected at sea and made accustomed to feed on the food given by man; a system of commercial culture starting with artificial fertilization has not yet been practised in any of these fishes. This situation is the outcome of economic considerations in the case of most species, and it is not that the artificial fertilization and/or the rearing of young are technically impossible. Artificial fertilization has been successful, at least experimentally, in most of these fishes, though there is little prospect of the success in the case of the conger eel (Asteroconger myriaster)., in which species mature individuals ready for spawning are extremely difficult to obtain. Rearing of the hatched larvae has not been successful, even experimentally, in the fishes with pelagic eggs; in the fishes with adhesive eggs, however, the hatched larvae can be reared without much difficulty. Experimental results suggest that newly hatched larvae of the puffer (Fugu rubripes) and the halfbeak (Hemiramphus sajor) can be reared in quantities up to the size useful as the seedling.

7. The octopus (Octopus vulgaris) is the only cephaloped now commercially cultured, but it is foreseen that the four cuttlefishes listed in TABLE 1 will be commercially cultured in near future, because pilot tests for their commercial culture have been successful. In the commercial culture of these cephalopods, either the seedling captured at sea or the naturally laid eggs (which are collected at sea and incubated artificially) can serve as the starting point. At present, the former is adopted in most cases.

8. The prawn, spiny lobster (Panulirus japonicus) and blue crab (Portunus trituberculatus) are the major crustaceans that are either cultured or 'live-kept' in commercial scale. While the 'live-keeping' of the prawn and its culture starting with the naturally produced seedling have been practised for many years in this country, a method of culturing this crustacean from the artificially fertilized egg through larval stages upto marketable size has recently been established and put into commercial operation. In the blue crab

(Portumus trituberculatus) and spiny lobster (Panulirus japonicus), artificial fertilization has been successful, but the technique of raising the hatched larvae in quantities upto the size of seedling has not been developed. At present, commercial cultures of the latter two species start with the naturally produced seedling captured at sea, and should be regarded as the 'live-keeping' rather than the culture, because the animal does not grow much during the period under confinement.

9. Among the marine shellfishes commercially cultured in Japanese inshore waters, the seven species listed in TABLE 1 are comparatively important. Artificial fertilization has been successful in all these species, and there are promising indications that their larvae can be raised upto the size of seedlings in quantities. In practice, however, all the species are raised from naturally produced spat, because these spat can be obtained without much difficulty.

III. MAJOR CULTURE METHODS

10. The various culture methods used in the culture of the above-named marine animals fall under one of the following two categories: the "culture in confinement" and the "culture without confinement". The culture methods of the first category are used for those locomotive forms which would disperse unless adequately confined, while the methods of the second category are used for the sedentary forms which, like most shellfishes, show little tendency towards dispersing Culture methods of each category are described below.

Cultures in confinement

11. The culture methods coming within this category can be classified into the following five types according to the types of installation for confining fish.

(a) Culture in the floating net: This method has developed primaril y for rearing the fish of the size of seedlings but it is recently used for the fish of larger sizes as well. The floating net is a cubic bag of synthetic fiber netting, consisting of four sides and a bottom; it is suspended down from a thick wooden frame which floats on the sea surface and is anchored in place. The size of floating nets is various, and the nets used for culturing fish of marketable size are larger than those used for culturing the seedling. It is foreseen that the use of the floating net will become increasingly popular in raising the fish of marketable size, because the installation is not expensive and is very convenient for taking good care of fish. PLATE I shows an example of the floating net (used for culturing seed-fish).

(b) Culture in the pound net: This method, commonly known as the "pile method", is used for culturing the fish of marketable size. The pound net is an encircling fence of wire or synthetic fiber netting supported by concrete piles or steel pipes driven into the sea bottom; the fence extends vertically from the sea bottom to a level well above the sea surface, and forms a complete enclosure in plan. Advantages of a pound net are generally good circulation of water and relatively small cost of construction. (PLATE II) (PLATE III).

(c) Culture in the net-fenced bay: In this method fish are cultured in a small bay the mouth of which is fenced with the wire netting of

fishing net supported by a row of piles; the installation is usually much larger in scale than in the foregoing types. An example of the net-fenced bay is illustrated in PLATE IV.

(d) Culture in the dammed bay: Fish are cultured in a bay the mouth of which is closed with an artificially constructed dike. This dike is provided with one or more water-gates, through which water flows in and out of the bay with tides. This type of installation is rarely built in recent years because of the expensiveness of construction and the difficulty of finding a site with suitable topography.

(e) Culture in the compartment-type cage: This method is used chiefly for culturing the octopus, which is cannibalistic. The cage is made of perforated wooden board or wire screen or combination of both. Its inside is partioned into a number of compartments, each of which accommodates one individual of octopus, whereby cannibalism is prevented. The cage is securely anchored in a place where the tidal current is strong enough for maintaining good circulation of water through the meshes of netting or through the perforations of the wooden board. At present, the cages used for octopus culture are not very large, usually measuring about 2 x 2 x 1 m with about 120 compartments.

12. Aside from the foregoing types of installation some aquiculturists raise the prawn or the conger eel (Asteroconger myriaster) in sea-water ponds constructed on land. Though this type of pond is comparatively expensive to construct, it has a great advantage that cultured fish can be cared for very well. One of the modernized fish-farms of sea-water pond type, in which the ponds have been built by new techniques and equipped with apparatus for agitation, aeration, etc., is reminiscent of a "fish culture factory".

13. Artificial fertilization, incubation, and rearing of larval stages have sofar been carried out chiefly in indoor tanks or in sea-water ponds on land. There is a tendency towards employing rearing tanks of re-circulating type for these purposes, because efficient and convenient re-circulating tanks have been designed recently.

Cultures without confinement

14. The culture methods classified under this category are used for culturing sedentary shellfishes and crustaceans and for seaweed culture.

(a) Raft culture: The representative examples of the raft culture are oyster culture and pearl culture. The animal to be cultured is suspended in water from the raft floating on the sea surface. In oyster culture, the strings of cultch to which oyster spat have settled are suspended from the raft; in pearl culture, pearl oysters are either placed in baskets or attached to strings, and are suspended from the raft. The size of the raft is various, but usually does not exceed 200 m^2. (PLATE V) (PLATE VI).

(b) Sowing culture: Various bivalves are cultured by this method. The seed, which attach to substrata in some species (e.g., ark shell, etc.) but not in other species (e.g., little-neck clam, hard clam, etc.), are collected in the area where they are abundant, and "sown over the culture bed", that is, transplanted to the area suitable for their subsequent growth. Though primitive, this method has an

advantage in being inexpensive. Those animals which have comparatively small locomotive power and take years to attain marketable size, such as the abalone (Haliotis gigantea), are also cultured by this method.

IV. SOME PRACTICAL PROBLEMS ENCOUNTERED IN MARINE AQUICULTURE

15. In those cultures classified as "cultures in confinement" fish are fed by man, whereas no artificial feeding is involved - cultured animals are left to feed on natural food - in the cultures classified as the "cultures without confinement". In this respect, the two major groups of culture methods fundamentally differ from each other. It sometimes happens, of course, that fish or other marine animals are cultured within an enclosure without artificial feeding, but such a crude method is rarely practised in recent years.

16. Installations for marine aquiculture are located of necessity in the sea or on the sea-shore. Therefore they may be easily attacked by storms, high tides and other natural disasters. It is essential to choose a site that is shown by statistics not to be affested by natural disasters, and to allow each installation sufficient structural strength to endure probable natural attacks.

17. Whatever species may be cultured, it is important that the installation for confining fish allows good exchange of water. Each installation should be of a size that is convenient for taking care of fish, and excessively large installations should be avoided.

18. It is difficult to make any general statement as to the material of food and the method of preparing food, because different species requires different food. It may be safely said, however, that every species needs some amount of fresh meat (i.e., fish meat, shallfish meat or others), and that a cold storage for preserving fresh fish food is needed if a species requiring much fresh meat is to be reared in large quantities.

19. In a culture that starts with natural seedling captured at sea, it is important to sort the seedling according to their size and to rear those of similar size in each enclosure. The use of a fish sorter is recommended in this connection.

20. Different species require different amounts of food. Care should be exerted so that the water of the culturing site may not be contaminated by the decomposition of left-over food.

21. It is noticeable that the optimal density of fish in an enclosure depends not only on the species and size of the fish but also on the structure and dimension of the enclosure. To our regret, standard density of fish has not yet been formulated in most types of marine aquiculture.

22. Success or failure of shellfish culture without confinement largely depends on whether or not the environmental condition of the culture ground is suitable for the cultured species. In choosing a shellfish species to be cultured in a given body of water, one ought to consider, in addition to topography, temperature, salinity, etc., the quality and quantity of natural food available in that water. The author and his colleague have

been selecting suitable species to be cultured in each body of water on the basis of the a - Cl diagram, and this method has been proving successful. In that diagram, a refers to the "suspension factor" and its value reflects the average size of suspended particles, while Cl stands for chlorinity (‰).

23. A marine aquiculturist ought to guard against fish diseases and parasites, because these are prone to occur in an intensive fish culture.

TABLE 1. Major cultured species and development in artificial productior of their seedling.

Japanese, English * and Scientific name	Culture of marketable size		Culture of Seedling#	Methods of obtaining fertilized eggs#	
	Scale	Seedling		Collection at sea	Artificial fertilization
Hamachi: Yellowtail *Seriola quinqueratiata*	commercial	natural	commercial		
Bora: Mullet *Mugil cephalus*	commercial	natural	commercial		
Maanago: Conger eel *Astroconger myriaster*	commercial	natural	commercial		
Suzuki: Sea bass *Lateolabrax japonicus*	commercial	natural	commercial		possible
Madai: Sea bream *Chrysophrys major*	commercial	natural	commercial		possible
Kurodai: Sea bream *Mylio macrocephalus*	commercial	natural	commercial		possible
Umazurahagi: Trigger fish *Navodon modestus*	commercial	natural	commercial		possible
Kawahagi: Trigger fish *Stephanolepis cirrhifer*	commercial	natural	commercial		possible
Torafugu: Puffer *Fugu rubripes*	commercial	natural culture	commercial	possible	possible
Shimaaji: Jack *Caranx delicatissiums*	commercial	natural	commercial		possible
Kanpachi: Yellowtail *Seriola purpurascens*	commercial	natural	commercial		possible
Ishidai: Parrot bass *Oplegnathus fasciatus*	experiment	natural	possible		possible
Ishigakidai: Parrot bass *Oplegnathus punctatus*	experiment	natural	possible		possible
Tsumuburi: *Elagatis bipinnulata*	experiment	natural	possible		?
Chidai: Sea bream *Evynnis japonica*	experiment	natural	possible		possible
Sayori: Halforak *Hemiramphus sajori*	experiment	culture	under study	possible	possible
Shiriyakeika: Cuttlefish *Sepiella maindroni*	experiment	natural culture	possible	possible	
Kaminariika: Cuttlefish *Sepia subaculeata*	experiment	natural culture	possible	possible	
Koika: Cuttlefish	experiment	natural culture	possible	possible	

(Cont'd)

Japanese, English* and Scientific name	Culture of marketable size: Scale	Culture of marketable size: Seed-ling	Culture of seedling#	Methods of obtaining fertilized eggs#: Collection at sea	Methods of obtaining fertilized eggs#: Artificial fertilization
Sepia esculenta					
Aoriika: Cuttlefish	experiment	natural culture	possible	possible	
Sepioteuthis lessoniana					
Madako: Octopus	commercial	natural culture	commercial+	commercial+	under study
Octopus vulgaris					
Kurumaebi: Prawn	commercial	natural culture	commercial		commercial
Penseus japonicus					
Iseebi: Spiny lobster	commercial	natural	commercial+		
Panulirus japonicus					
Gazami: Blue crab	commercial	natural	commercial+		
Portunus trituberculatus					
Mogai: Ark shell	commercial	natural cultured	commercial		
Anadara subcrenata					
Akoyagai: Pearl oyster	commercial	natural cultured	commercial		
Pteria martensii					
Hotategai: Scallop	commercial	natural cultured	commercial		
Pecten yessoensis					
Magaki: Oyster	commercial	natural cultured	commercial		
Ostrea gigas					
Asari: Littleneck clam	commercial	natural	commercial		
Venerupis philippinarum					
Hamaguri: Hard clam	commercial	natural	commercial		
Meretrix meretrix lusoria					
Awabi: Abalone	commercial	natural	commercial		
Haliotis gigantea discus					

* English common name in parentheses.
+ Live-keeping; the growth of fish is not much aimed at.
# "Commercial" ..... Commercially practised.
"Possible" ..... Technique established by research, but not yet practised.

Plate I. An example of the floating net

Plate II. An example of the pound net

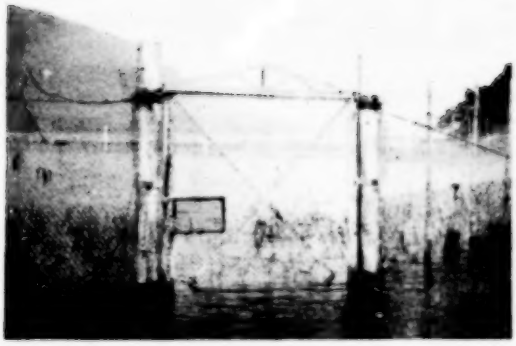

Plate III. An example of the pound net (Gate)

Plate IV. An example of the net-fenced bay

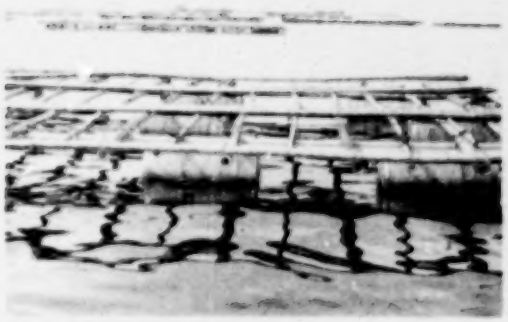

Plate V. An example of the raft (Oyster culture)

Plate VI. An example of the raft
(Oyster seedling culture)

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